

**EOS Aura Science Team Meeting**  
**Pasadena, California**  
**August 27th – 29th, 2019**

**Mission Operations Working Group (MOWG)**  
**Report to the Aura Science Team**

**Presented by Dominic M. Fisher,**  
**Aura Mission Director (GSFC – ESMO - Code 428/584)**

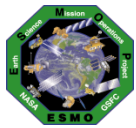
**[dominic.m.fisher@nasa.gov](mailto:dominic.m.fisher@nasa.gov)**



# Aura Mission Operations Working Group (MOWG)

***The MOWG, established in 1997, is dedicated to ensuring the health and safety of the Aura satellite (spacecraft bus and instruments) to enable science observations.***

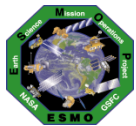
**22 years of collaboration between the various Ops teams!**



# 2019 Aura IOT/FOT MOWG Meeting Attendees



**August 27, 2019  
Pasadena,  
California**



# 2019 Aura IOT / FOT MOWG Meeting

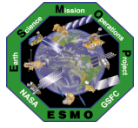
## (August 27th, 2019)



<u>Name</u>	<u>Affiliation</u>
Bill Guit	Aqua MD / ESMO / GSFC
Brian Knosp	JPL
Charles Webb	NASA HQ / ESD / Program Executive
Cheryl Asbury	TES / JPL
Chuck Hudson	Aura FSM / EOS / GSFC
Dominic Fisher	Aura MD / ESMO / GSFC
Elena Trenholme	Aura FDS / EOS / GSFC
Jacob Williams	Aura Instruments / EOS / GSFC
Len Dorsky	TES / JPL
Matt Donnelly	Aqua Instruments / EOS / GSFC
Mirna van Hoek *	OMI IOT Lead / KNMI
Nico Rozemeijer	OMI / KNMI
Paul Wagner	JPL
Phil Durbin	SED / GSFC
Quintus Kleipool	OMI / KNMI
Richard Lay	MLS & TES PM / JPL
Rick Cofield	MLS / JPL
Ryan Fuller	MLS IOT / JPL
Tiffany Hoerbelt	FDS Lead / ESMO / GSFC

\* Remote  
Support



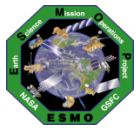


# Aura IOT / FOT MOWG

## Key Meeting Objectives



- **Discuss current Aura spacecraft and instrument status**
- **Highlight any performance trends of note and project any impacts to continued operations**
- **Identify any operational changes that may be needed to ensure continued Aura operations**
- **Express any concerns or potential process improvements (i.e., any interface / ground system issues)**
- **Discuss future Aura spacecraft and instrument plans (i.e., A-train exit plans)**
- **Discuss preparations for 2020 Senior Review**

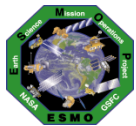


# Aura IOT / FOT MOWG Meeting Agenda

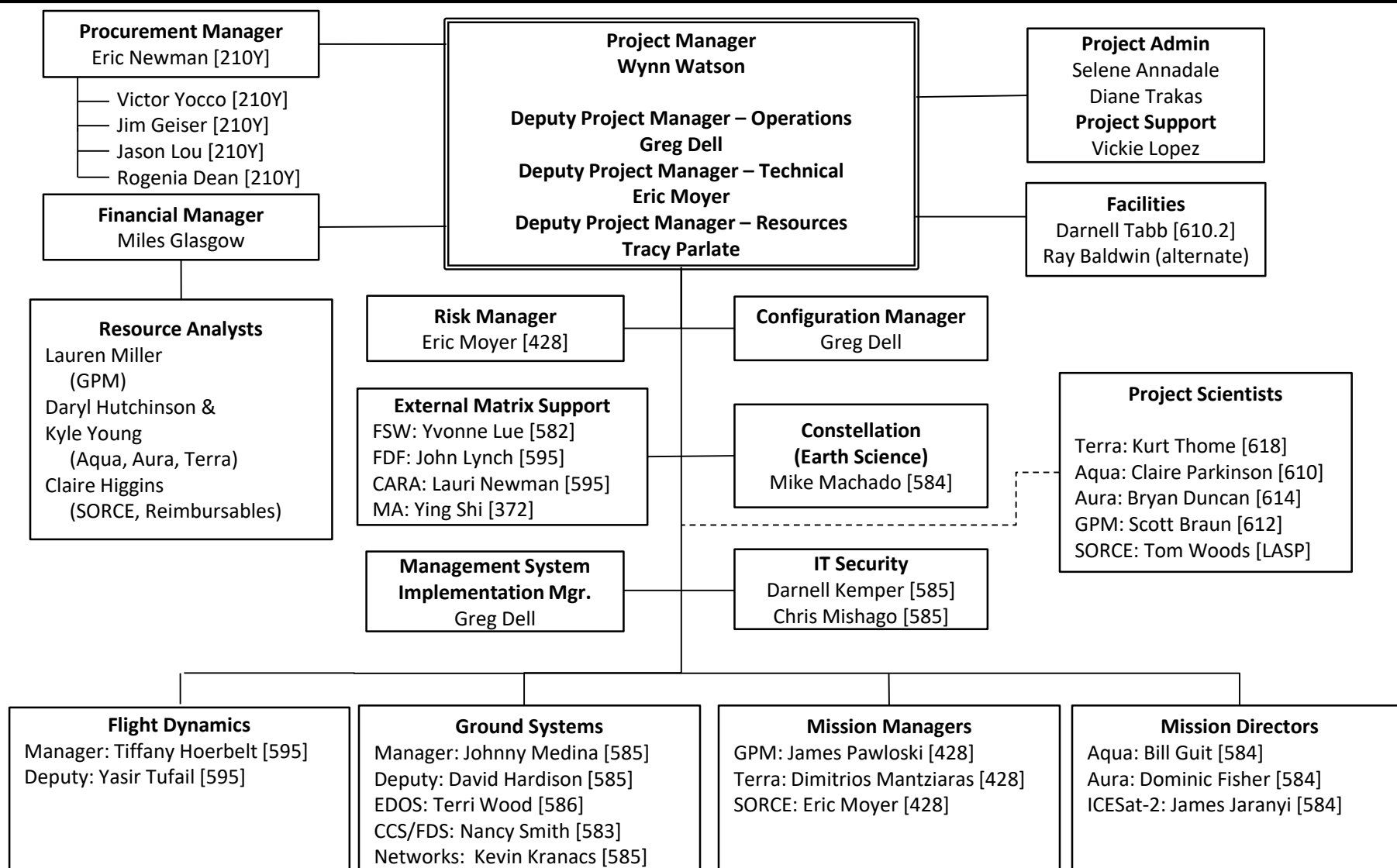
(August 27, 2019)



Time	Topic	Presenter
01:30	Welcome / Introduction	Fisher / All
01:35	GSFC ESMO Updates	Fisher
01:40	Aura Mission Status	Fisher
02:00	OMI Instrument Status	Van Hoek
02:20	Aura Spacecraft / EOS Ground System Status	Hudson
02:40	EOS FDS Status	Trenholme
<b>03:00</b>	<b>BREAK ( *Group Photo* )</b>	
03:10	MLS Instrument Status	Fuller
03:30	TES Instrument Status (including Special Topic: Laser Testing Results)	Lay
04:00	Summary / Review Actions	All

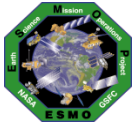


# ESMO Organization









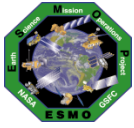
# Aura Spacecraft Subsystems

- **Command & Data Handling (CDH) – Nominal**
  - **Formatter Multiplexer Unit (FMU) / Solid State Recorder (SSR) Anomaly**
    - » Initial symptoms occurred December 4-18, 2007
    - » Newest symptoms started in January 2017 and remain active (impacting S-Band HK data capture)
- **Communications (COMM) – Nominal**
  - **Transmitter-B Reflected Power Anomaly (10/17/17, 01/05/18)**
- **Electrical Power System (EPS) – Nominal**
  - **Array Regulator Electronics (ARE) Anomalies:**
    - » *Solar Panel Connector Anomaly – ARE-3C (01/12/05) – loss of ~11 strings*
    - » *MMOD Strike – ARE-5A (03/12/10) – loss of ~6 strings*
  - **ARE Degradation (due to aging):**
    - » *ARE-5C (9/27/12, 2/4/13), ARE-1A (3/12/10, 11/5/11), ARE-5A (4/25/13), ARE-6A (9/14/13), ARE-4A (9/23/14, 12/8/14), ARE-1C (7/14/17, 12/22/17), ARE-2C (8/18/17)*
    - » *Estimated that Aura has lost 29 strings of solar cells out of a total of 132 strings (~78.0% remain)*
    - » *Aura continues to have significant power margin where the life limiting item is fuel*
- **Flight Software (FSW) – Nominal**
- **Guidance, Navigation & Control (GN&C) – Nominal**
- **Propulsion (PROP) – Nominal**
- **Thermal Control System (TCS) – Nominal**

**All subsystems configured to primary hardware**



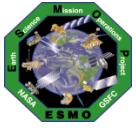
- **0 Spacecraft Bus Anomalies**
- **2 Instrument Anomalies**
  - **0 OMI Anomalies**
  - **2 MLS Anomalies**
    - » 1 Survival Mode Transition (01/27/19, recovered on 01/31/19)
      - TMON 19 (Stale Telemetry Monitor) triggered while in SAA region – same as July 2018 event
    - » 1 Receiver 2 Anomaly (07/18/19, recovered on 07/24/19)
      - 190 GHz R2 Receiver signal chain anomaly - identical to the occurrence in October 2012
- **13 Spacecraft Maneuvers**
  - **9 Drag Make-up Maneuvers (DMUMs # 118 – 126)**
    - » Routine: 01/17/19, 02/07/19, 04/17/19, 05/08/19, 05/30/19, 06/26/19, 07/18/19, & 08/15/19; Debris Avoidance Maneuver (DAM): 03/19/19
  - **4 Inclination Adjust Maneuvers (IAMs #59, #60, #61, #62)**
    - » IAM series completed successfully on 03/06/19, 03/13/19, 04/03/19, & 04/10/19
    - » First series to utilize the new reaction wheel yaw slew approach, instead of thruster based
    - » IAM #59 performance was ~12% COLD due to using simulated reaction wheel inputs
    - » Continue to observe degraded propulsion system performance
- **1 Instrument Calibration Maneuvers**
  - **MLS Yaw & Moon Scan #14 (03/22/19)**



# Summary of Activities (2019)



- **9 High Interest Orbital Debris Events (As of 07/31/19)**
  - 8 required planning and screening maneuver options (Tier 3)
  - 1 required executing a Debris Avoidance Maneuver (DAM) (Tier 4)
    - » Aura vs. 87932, TCA on 03/20/2019 @ 03:17:19 GMT
- **Partial Government Shutdown (12/22/18 – 01/25/19, 35 days)**
  - Postponed Aura Decommissioning Peer Review (\*DRAFT\*), Aura Science Team Meeting, ESMO Annual Review, CARA Devolution, Service Management Legacy Adapter Replacement Testing
- **TES Post-Decommissioning [Laser End-of-Life (EOL) Testing]**
  - TES decommissioning activities completed back on 01/31/18
  - Phase 1 Testing – 6-weeks of tests back in June & July 2018
  - Phase 2 Testing (ongoing) - Round 1 (November 2018) & Round 2 (April 2019)
- **CARA Devolution (Shifting Conjunction Assessment over to Mission Operations)**
  - Worked through updating documentation (MOU, Ops Con, Test Plan, etc.)
  - Continuing with Parallel Operations – working through planned success criteria
    - » CARA Devolution TRR held on 03/25/19; Parallel Ops started on 03/26/19

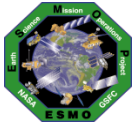


# Summary of Activities (2019)



- **Aqua / Aura Maneuver Working Group**
  - Thruster Performance Degradation Investigation
  - Aqua RWA IAM Development
  - Aqua/Aura IAM Planning
  - Develop Retrograde Maneuver Capability for Aqua/Aura
- **Earth Science Constellation (ESC) Mission Ops Working Group (MOWG)**
  - Last Meeting: June 5th – 7th, 2019 @ Toulouse, France
  - Next Meeting: December 3<sup>rd</sup> – 5<sup>th</sup>, 2019 @ Gilbert, AZ
  - Present Aura Mission Status to the other member missions
  - Include updated lifetime and decommissioning plans
- **TrollSat Ground Station certification**
  - Mitigating potential scheduling conflicts with OCO-2 (Norway antennas)
  - Building off of successful testing that occurred in 2012 (X-Band downlink only)
  - EDOS has existing hardware to capture and deliver science data (SMAP)
  - FOT is identifying and developing ground system updates to accomodate





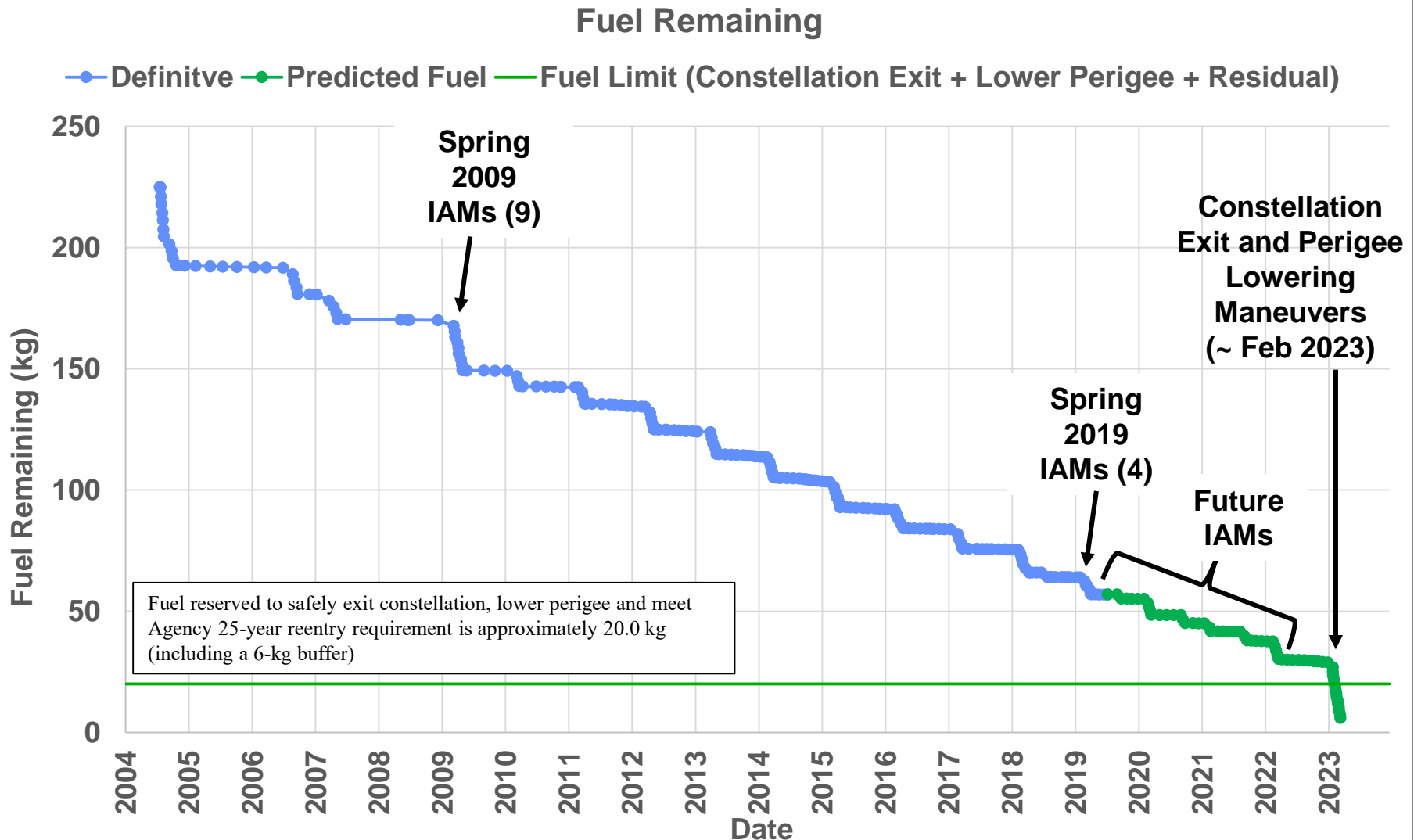
# Upcoming Planned Activities

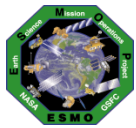
- **Aqua/Aura Maneuver Working Group:**
  - Continue Thruster Degradation Investigation
  - Aqua RWA Test Maneuver (#1) – November 2019
- **EOS Automation (EA) – automation of routine operations**
  - » EA Phase 3.3 – Fall 2019
- **Conjunction Assessment (CA) - continue to improve DAM execution**
  - » Complete parallel operations pilot program between ESMO / CARA – Fall 2019
- **October 2019: Fall Inclination Adjust Maneuver (1) – 10/03/19 (#63)**
- **December 2019: Earth Science Constellation (ESC) MOWG (Gilbert, AZ)**
  - Update propellant budget, decommissioning analysis, reliability predictions, etc.
- **January 2020: ESMO Annual Review #13**
- **March 2020: Senior Review Proposal submission**
- **March 2020: Spring Inclination Adjust Maneuvers (4)**
  - 3/4/20 (#64), 3/11/20 (#65), 3/18/20 (#66), 3/25/20 (#67), 4/1/20 (B/U)
- **Summer 2020: Earth Science Constellation (ESC) MOWG**
  - Update propellant budget, decommissioning analysis, reliability predictions, etc.



# Fuel Usage: **Actual** & **Predicted**

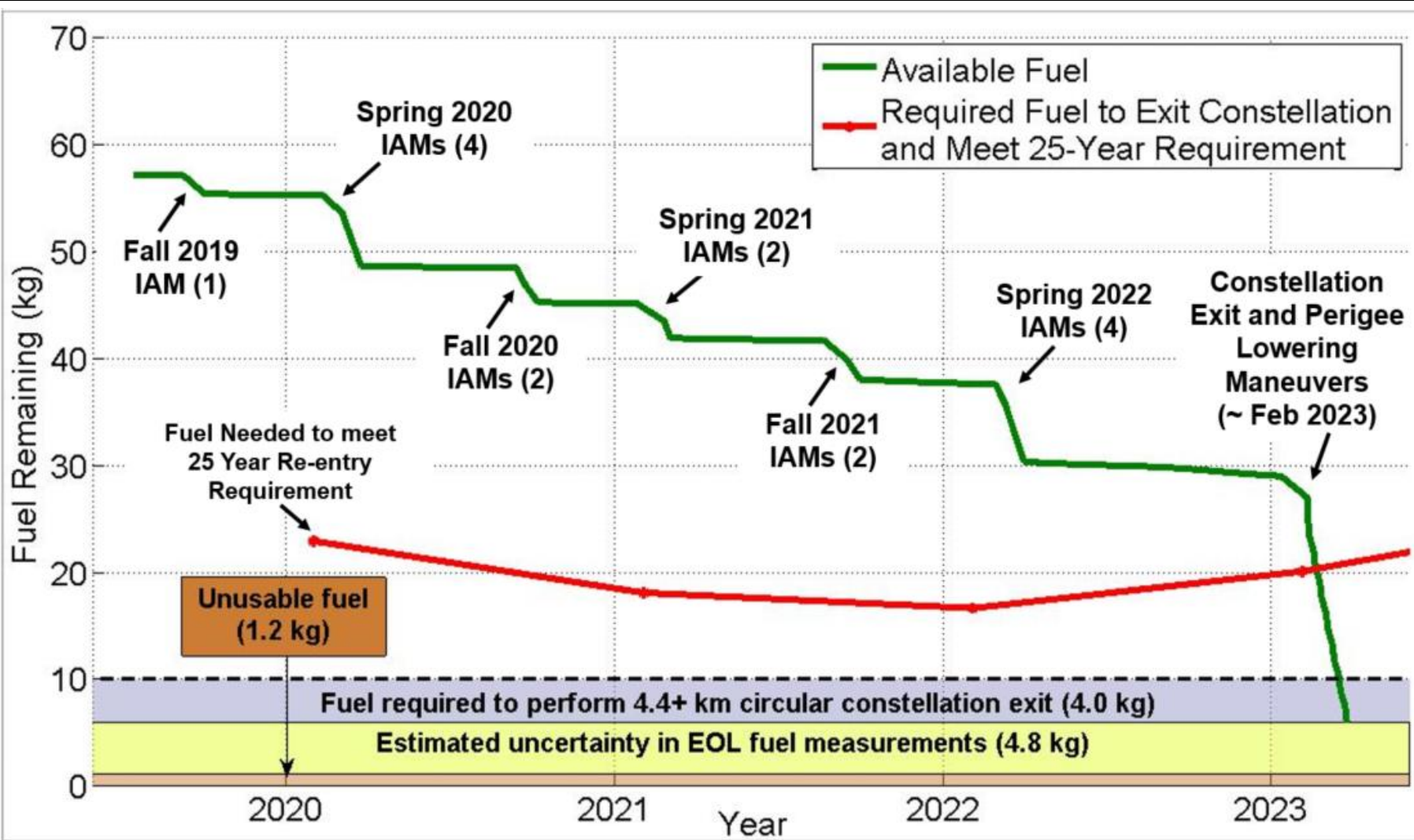
(Baseline Fuel Plan – Analysis Updated August 2019)

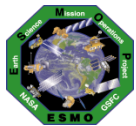




# Aura End of Life Predictions

(Baseline Fuel Plan – Analysis Updated August 2019)



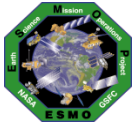


# Overall Summary



- **Spacecraft Status – GREEN**
- **Instrument Status - GREEN**
  - HIRDLS: Chopper Stalled 03/17/08 – Not collecting science data
  - MLS: Operating Normally (Only periodic Band 13 measurements)
    - » 06/04/2018: 118 GHz Receiver-1A (R1A) Anomaly (Recovered 06/11/18)
    - » 06/20/2018: GHz Mirror Electronics (GME-B) Anomaly (Recovered 06/26/18)
    - » 07/10/2018: MLS Survival Mode Transition (Recovered 07/18/18)
    - » 10/25/2018: GHz Mirror Electronics (GME-B) Anomaly (Recovered 10/25/18)
    - » 01/27/2019: MLS Survival Mode Transition (Recovered 01/31/19)
    - » 07/18/2019: 190 GHz Receiver-2 (R2) Anomaly (Recovered 07/24/19)
  - OMI: Operating Normally
    - » 07/30/2018: OMI IAM Warm Restart (Recovered 07/31/18)
  - TES: Instrument Decommissioned on 01/31/18
- **Data Capture/L0 Processing Status – GREEN**
  - SSR Data Capture to 07/31/19: 99.99505737%
- **Ground Systems – GREEN**
  - Responding to new security requirements and upgrades to obsolete hardware or COTS systems, as required
  - 12/18/2018: Online (Eclipse) Build 21.01 ORR
  - 02/06/2019: EOS Automation (EA) Release 3.2.2 eORR


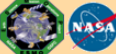





# Flight Operations Team (FOT) Status



- **Data Capture Rates continue to be stellar (+99.99%)**
- **Spacecraft risks remain stable with FMU/SSR anomaly recovery and degrading solar array strings remain the top risk**
- **Continue to review any outdated Operations Agreements with IOTs**
- **Reviewing Instrument Safe / Survival SOPs with IOTs**
- **FOT capturing routine instrument activities in standard operating procedures**
- **Successfully executed a new approach for IAMs utilizing the reaction wheels in Spring 2019**
- **FOT automation efforts continue to include on-board solutions and process improvement procedures**



## Aura FOT/IOT MOWG

August 27, 2019

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Aura Flight Systems Manager  
Phone: (301) 614-5104  
Charles.M.Hudson-1@nasa.gov

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# MLS Instrument Operations Team (IOT) Status



Earth Observing Systems  
Microwave Limb Sounder



## MLS Instrument Operations Status Update

Ryan Fuller

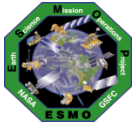
Jet Propulsion Laboratory  
California Institute of Technology  
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Pasadena, CA  
August 27, 2019

8/27/19

Page 1

- **MLS GHz mechanisms continue to operate within their nominal range**
- **AAA continues to perform well**
- **MLS THz mechanism has had limited periods of operation (stand-by mode since 2014)**
- **Significant events this year included Survival Recovery, Moon Track #14,, and SIF2 / R2 Anomaly**
- **Continue with MLS routine and calibration activities, including AAA reconditioning, spectral baseline updates, and EEPROM checksum verification**
- **Next Moon Track (#15) targeted for March 2020**
- **No THz OH measurements planned**
- **Monitor components temperature and voltages, adjust if necessary**

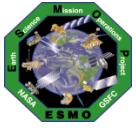


# OMI Instrument Operations Team (IOT) Status

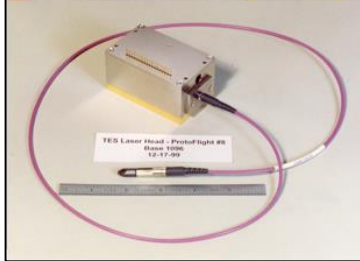
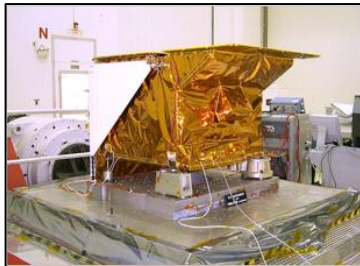


- **There have been 0 anomalies in 2019; compared to 3 anomalies in 2018 (only 6 since launch):**
  - No OMI-IAM warm restarts around the SAA in 2019
  - No impact on science quality
- **Instrument performs nominally (with exception of row anomaly)**
- **CCD temperatures are very stable**
- **All three mechanisms behaving nominally**
- **Life limited items (mechanisms, internal calibration source) still within budget**
- **Instrument degradation is very slow**
- **>99% of all measurements are according to Nominal Operations Baseline**
- **Investigating changes needed for the baseline after exiting the A-train**





# TES Post-Decommissioning Status

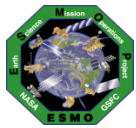


## TES Lasers EOL Test Results (through April 2019)

Cheryl Asbury, Len Dorsky, Mathieu Eradet  
Jet Propulsion Laboratory, California Institute of Technology  
August 27, 2019

- TES decommissioning activities completed back on 01/31/18
- Continue to perform TES Laser End-of-Life (EOL) Testing
- Phase 1 Testing –
  - 6-weeks of tests back in June & July 2018
- Phase 2 Testing (ongoing) –
  - Round 1 (November 2018) & Round 2 (April 2019)
- Beginning to ferret out aging differences between operating and non-operating, and between ground and flight
- Phase 2 Testing Round 3 planned for October 2019 (and every 6 months)
- Continue testing of ground lasers in FY20





# Aura MOWG Meeting Action Items



## Action Items Captured

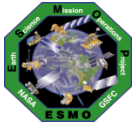
	Determine updates to activities and products needed after A-Train exit and coordinate a transition timeline	FOT / OMI and MLS IOTs
	Provide a description of instrument activities (present and future) and the roles & responsibilities	OMI IOT
	Stand up new working group to discuss transition of OMI operational responsibilities	OMI IOT / FOT
	Understand the Near Realtime (NRT) data requirement and the number of users	FOT
	Review Safe / Survival Mode Standard Operating Procedures (SOPs)	FOT / IOTs
	Review instrument Operational Agreements (OA)	FOT / IOTs
	Coordinate expedited data requests following MLS AAA activities	FOT
	Prepare for 2020 Senior Review Proposal (Draft inputs due January 2020)	FOT / IOTs



# Summary

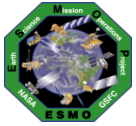


***The Mission Operations teams, both flight and instrument, are dedicated to keeping Aura operational for as long as possible***

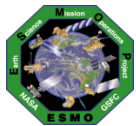


**Thank You  
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***Questions?***



# Back Up Slides



# Abbreviations / Acronyms List

AAA –	Antenna Actuator Assembly	FSM –	Flight Systems Manager	MOU –	Memorandum of Understanding
ARE –	Array Regulator Electronics	FSW –	Flight Software	MOWG –	Mission Operations Working Group
A-Train –	Afternoon Constellation	GHz –	Gigahertz	NASA –	National Aeronautics & Space Administration
CA –	Conjunction Assessment	GME –	GHz Mirror Electronics	OA –	Operations Agreement
CARA –	Conjunction Assessment Risk Analysis	GNC –	Guidance Navigation & Control	OCO-2 –	Orbiting Carbon Observatory 2
CCD –	Charge Coupled Device	GPM –	Global Precipitation Measurement	OMI –	Ozone Monitoring Instrument
CCS –	Constellation Coordination System	GSFC –	Goddard Space Flight Center	ORR –	Operational Readiness Review
CDH –	Command & Data Handling	HIE –	High Interest Event	PM –	Project Manager
COMM –	Communications	HIRDLS –	High Resolution Dynamics Limb Sounder	PROP –	Propulsion
COTS –	Commercial-off-the-Shelf	HK –	Housekeeping	R1A –	Receiver-1A
DAM –	Debris Avoidance Maneuver	HQ –	Headquarters	R2 –	Receiver 2
DMUM –	Drag Make-up Maneuver	IAM –	Inclination Adjustment Maneuver or Interface Adapter Module	RWA –	Reaction Wheel Assembly
EA –	EOS Automation	IOT –	Instrument Operations Team	SAA –	South Atlantic Anomaly
EDOS –	EOS Data & Operations System	IT –	Information Technology	SED –	Science & Engineering Division
EEPROM –	Electrically Erasable Programmable Read-Only Memory	JPL –	Jet Propulsion Lab	SMAP –	Soil Moisture Active Passive
EOL –	End of Life	kg –	kilogram	SMLA-R –	Service Management Legacy Adapter Replacement
EOS –	Earth Observing System	km –	kilometer	SOP –	Standard Operating Procedure
EPS –	Electrical Power System	KNMI –	Royal Netherlands Meteorological Institute	SORCE –	SOLar Radiation & Climate Experiment
ESC –	Earth Science Constellation	L0 –	Level-Zero	SSR –	Solid State Recorder
ESD –	Earth Science Division	MA –	Mission Assurance	TCA –	Time of Closest Approach
ESMO –	Earth Science Mission Operations	MD –	Mission Director	TCS –	Thermal Control System
FDF –	Flight Dynamics Facility	MLS –	Microwave Limb Sounder	TES –	Tropospheric Emissions Spectrometer
FDS –	Flight Dynamics System	MLT –	Mean Local Time	TMON –	Telemetry Monitor
FMU –	Formatter Multiplexer Unit	MMOD –	Micrometeorite Orbital Debris	TRR –	Test Readiness Review
FOT –	Flight Operations Team	MMS –	Mission Management System		
		MO –	Mission Operations		